Late Pleistocene human occupation in the Maloti-Drakensberg region of southern Africa: new radiocarbon dates from Rose Cottage Cave and inter-site comparisons

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ABSTRACT

Rose Cottage Cave, near Lesotho's western border with South Africa, is a rare archive of late Pleistocene hunter-gatherer behavioural variability in a montane environment, a setting that is poorly represented in regional ethnographic archives. Here, we present an updated chronology for the site based on high-resolution AMS radiocarbon dates and Bayesian and Kernel Density Estimation (KDE) methods. We draw on broader anthropological approaches to lithic evidence and behavioural modelling to test hypotheses about hunter-gatherer provisioning and mobility systems across the Maloti-Drakensberg Escarpment biogeographical transect. We compare the modelled ages and stone tool evidence from Rose Cottage Cave to other well-dated archaeological sequences in the region, including the comparably well-dated site of Sehonghong in highland Lesotho, as well as Ha Makotoko, Ntloana Tšoana, and Strathalan sites A and B. These comparisons reveal differences in the organization of lithic technologies and activity traces across the region, which can be explained by a combination of responses in hunter-gatherer mobility to local environmental gradients and climate shifts during the climatically variable late Pleistocene. Our results shed light on the relationship between patterns of behavioural change and palaeoenvironmental variability in southeastern southern Africa specifically, and on hunter-gatherer behavioural variability in montane environments more generally.

Key words: AMS radiocarbon dates, Bayesian model, Last Glacial Maximum, Later Stone Age, Middle Stone Age, late Pleistocene, southern Africa, hunter-gatherers, behavioural variability, palaeoenvironment

1. Introduction

Marine Isotope Stages (MIS) 3 and 2 (*c.* 57–29 ka and *c.* 29–14 ka, respectively) saw marked cultural changes across southern Africa. Arguably the most conspicuous of these was the transition from the Middle to the Later Stone Age, which included a shift to miniaturized lithic technologies and the more regular and widespread adoption of compound hafted tools and symbolic material culture, including beads and other ornaments. Large-scale shifts in temperature and rainfall over this period, climaxing over the Last Glacial Maximum (LGM: regionally defined as 24-17.5 kcalBP; Chevalier and Chase, 2016; Fitchett et al., 2016), drove substantial palaeoenvironmental changes across much of the subcontinent, potentially framing adaptive responses from hunter-gatherer populations.

Southern Africa's southeastern interior (focused on the Maloti-Drakensberg Mountains of Lesotho and adjacent areas of South Africa) is an excellent region within which to investigate the cultural processes operating in both MIS 3 and MIS 2. Excavation, dating, and analysis of multiple archaeological sequences in recent decades (e.g. Carter et al., 1988; Opperman and Heydenrych, 1990; Mitchell, 1993, 1996a; Opperman, 1996a; Wadley, 1997; Stewart et al., 2012; Mitchell and Arthur, 2014), alongside increasingly detailed reconstructions of regional palaeoenvironments (for reviews see Fitchett et al., 2016; Stewart and Mitchell, 2018a), has granted improved understandings of the regional archaeological sequence from MIS 3 onwards. The dramatic relief of the Maloti-Drakensberg region structures strong temperature and precipitation gradients that were markedly affected by the climate shifts of the LGM and Pleistocene/Holocene transition (*c.* 14-11.5 ka). Researchers have developed hypotheses regarding hunter-gatherer occupation of the wider landscape (see section 1.3 below), and detailed comparisons of archaeological sites that span these environmental gradients can reveal population connections and hunter-gatherer movements across the landscape under varying climatic states. However, such comparisons depend heavily upon detailed and accurate site chronologies.

Rose Cottage Cave (29° 13'S, 27° 28'E; *c.* 1680 m a.s.l.) is a large rockshelter in the Caledon River corridor, Free State, South Africa, with a long sequence of hunter-gatherer occupation from before the Howiesons Poort (>65 ka) to the early nineteenth century AD. The site, which has been the focus of several excavations and detailed technological and palaeoecological research (Beaumont, 1978; Clark, 1999a; Malan, 1952; Wadley, 1997, 1991; Wadley et al., 1992), boasts one of the few regional archaeological sequences that is largely continuous across the late Pleistocene and Holocene. Indeed, the technological sequence at Rose Cottage Cave (RCC) helped to establish what is now commonly accepted as the general pattern for late Pleistocene archaeology in southern Africa — namely, that Later Stone Age (LSA) technocomplexes occurred much earlier than was once previously believed (Vogel and Marais, 1971) and that the transition between the Middle Stone Age (MSA) and LSA here was gradual, rather than sudden, with technological antecedents of miniaturized LSA technologies, such as the Robberg industry, observed in the site's Howiesons Poort and late MSA assemblages (Clark, 1999a, 1997a; Soriano et al., 2007). Yet, despite possessing one of the region's deepest and highest resolution cultural sequences, RCC's existing chronology — largely founded on now-outdated radiocarbon methods — presents several ambiguities and uncertainties in relation to other regional sites.

To redress this, we have conducted a new, targeted dating program together with a comprehensive re-evaluation of the site's temporal framework. This study reports new accelerator mass spectrometry (AMS) radiocarbon dates on previously excavated charcoal samples from RCC. The new AMS and previously published conventional radiocarbon dates are calibrated and modelled using Bayesian and Kernel Density Estimation (KDE) analyses to produce a site chronology. This chronology and associated lithic data are then compared to those from other adequately dated long-sequence archaeological sites whose locations form a biogeographical transect across the Maloti-Drakensberg Escarpment. Our results shed light on the relationship between patterns of behavioural change and palaeoenvironmental variability in southeastern southern Africa specifically, and on hunter-gatherer behavioural variability in montane environments more generally.

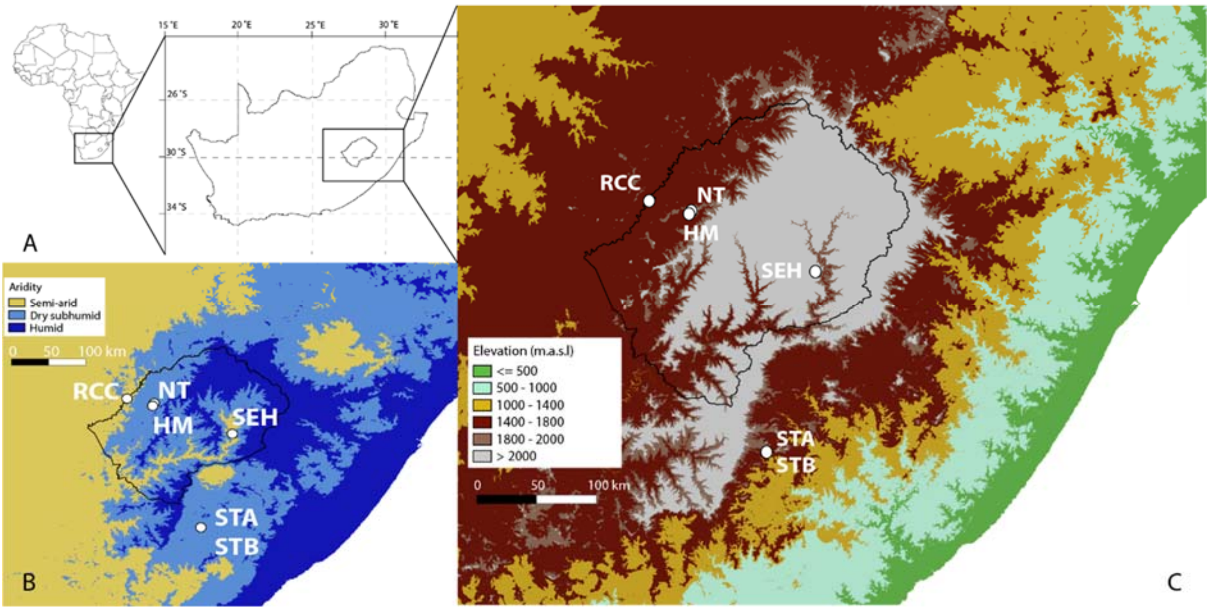

Figure 1 A) Location of the study area within Africa, B) modelled aridity zones across the Maloti-Drakensberg region, with the key sites discussed in the text indicated (aridity data from www.cgiar-csi.org, Zomer et al., 2008), C) digital elevation map of the study area, with sites discussed in text (90m SRTM data, Jarvis et al. 2008). Site names are abbreviated thus: HM Ha Makotoko; NT Ntloana Tšoana; RCC Rose Cottage Cave; SEH Sehonghong; STA Strathalan A; STB Strathalan B.

1.1 Late Pleistocene and Holocene palaeoenvironmental history

Rose Cottage Cave is situated in South Africa's eastern Free State province just west of the Caledon River, which today forms Lesotho's western border (Figure 1). The natural vegetation in the immediate vicinity is *Cymbopogon-Themeda* "sourveld" grassland (Acocks, 1975), which provides highly productive grazing during the summer-rainfall growing season, and bush and scrub thicket upon rocky sandstone outcrops. The immediate surrounds are sheltered from the worst of the cold weather extremes on adjacent highveld and high-altitude mountainous regions, and experience only moderately severe winter frosts. Detailed palaeoclimatic records are scarce for this region (Stewart and Mitchell, 2018a), but the available evidence suggests that regional temperatures were substantially cooler at the LGM and through to the Pleistocene/Holocene transition. Further east, where Lesotho's highlands meet the uKhahlamba-Drakensberg Escarpment that defines the country's eastern border with South Africa, the highest Maloti-Drakensberg Mountains witnessed the development of periglacial features during the LGM, albeit that they are likely to have been short-lived and restricted to shaded aspects (Mills et al., 2012). Grassland vegetation belts, constrained by altitudinal temperature gradients, were lowered by hundreds of metres during the terminal Pleistocene, indicating decreases in growing season temperatures of at least 5ºC (Loftus et al., 2015; Roberts et al., 2013; Smith et al., 2002; Stewart et al., 2016; Vogel et al., 1978). Syntheses of multiple pollen records in the interior summer rainfall region show that the coldest periods occurred *c.* 24 ka and 17.5 ka, with evidence for a slight relative warming between 20 and 19 ka (Scott et al., 2012; see also Chevalier and Chase, 2015 temperature reconstruction in

Figure 5 below). Post-glacial warming is evident in the highlands by *c.* 13.5 ka (Loftus et al., 2015; Neumann et al., 2014), although this warming trend was interrupted by rapid swings in temperature during the terminal Pleistocene, probably related to global climate events such as the Antarctic Cold Reversal (*c.* 14.5-13 ka) and/or the Younger Dryas (*c.* 13-11.5 ka) (Truc et al., 2013; Stewart and Mitchell, 2018a).

Reconstruction of regional hydrographic conditions has proven more difficult. Generally, the LGM has been considered a time of drier conditions across southern Africa's summer rainfall region (Deacon and Thackeray, 1984). This is because glacial aridification there has been linked to cooler Indian Ocean sea surface temperatures that limit available moisture (Chevalier and Chase, 2016; Truc et al., 2013). Charcoals from RCC itself indicate a cooler, drier, heathland environment during the terminal Pleistocene, shifting to moister conditions with increased tree and bush cover during the early Holocene (Plug and Engela, 1992; Wadley et al., 1992). Yet, given the LGM degree of cooling, the development of periglacial features at very high altitudes in the Maloti-Drakensberg Mountains suggests that regional conditions must have been either wetter than present during the LGM, or that a greater proportion of precipitation fell in winter, allowing ice and snow to persist on the ground year-round in high-altitude regions (Mills et al., 2012). Furthermore, Scott et al. (2012) argue from interpretations of several pollen archives suggesting drier conditions at this time that the influence of temperature decreases on vegetation has been underplayed. They propose instead that conditions in the Free State prior to the LGM and across the LGM were relatively cool and sub-humid, with some evidence for a dry climatic episode *c.* 22 ka. They also find evidence for a general trend towards drier conditions during the Younger Dryas *c.* 13-11.5 ka. These conflicting interpretations may be explained by the interaction between precipitation and temperature, which together determine aridity via evapotranspiration effects: the LGM temperature decline, in other words, offset the decrease in summer precipitation (Chevalier and Chase, 2016). Conversely, palaeoclimatic studies reconstruct variable but generally warmer and more humid conditions during the terminal Pleistocene and early Holocene (Truc et al., 2013).

That palaeoenvironmental studies in the Maloti-Drakensberg region have so far struggled to reconstruct straightforward responses to climatic trends may be due to a combination of the limited available datasets (Stewart and Mitchell, 2018a) and heterogeneous local environments resulting from its varied topography and a complex interplay of weather systems (Esterhuysen and Mitchell, 1997). The high Maloti-Drakensberg mountain ranges capture much of the region's summer precipitation, which is transported westwards by tropical climate systems originating in the Indian Ocean. Consequently, highland Lesotho and areas lying to the east of the Escarpment are substantially better watered than those under their rain shadow further west (Tyson and Preston-Whyte, 2000). Areas to the west of the Escarpment that lie within the rain shadow are likely to have been more readily affected by any drying trends that affected southern Africa's summer rainfall region as a whole. Today, the Caledon River corridor and its associated archaeological sequences lie at the modelled boundary between semi-arid and dry sub-humid regions (see Figure 1B; www.cgiar-csi.org, Zomer et al., 2008). Due to the rainfall gradient across this region, areas in highland Lesotho and below the Escarpment toward the Indian Ocean probably continued to receive adequate rainfall for longer than areas to the west. However, the region's foothills are less likely to have been affected by the seasonal extremes in temperature that occur at higher altitudes and make the Lesotho highlands a challenging environment in which to live even today (Moeletsi, 2004). Winter temperatures drop well below 0ºC in the highlands, and high-lying regions receive frequent, albeit short-lived, snowfalls (Grab et al., 2017).

1.2 Archaeological sequences across the Escarpment

Rose Cottage Cave is one of only a handful of excavated and dated sites in southernmost Africa with sufficient dates and adequately preserved and described stratigraphic sequences to allow archaeologists to closely investigate occupational histories across the late Pleistocene (Figure 1C) (Deacon, 1990). Another is Sehonghong (*c.* 1800 m a.s.l.), about 110 km to the east on a tributary of the Senqu (Orange) River in the Lesotho highlands (Carter et al., 1988; Mitchell, 1996b). This site features a comprehensive record of technological change encompassing MSA, early LSA, and LSA technocomplexes, such as the Robberg, Oakhurst and Wilton (see further discussion below), with a detailed chronology based on more than 60 AMS and conventional radiocarbon dates (Carter et al., 1988; Carter and Vogel, 1974; Loftus et al., 2015; Mitchell and Vogel, 1994). A recent paper using Bayesian modelling methods emphasized the highly punctuated nature of its occupation across the late Pleistocene and Holocene (Pargeter et al., 2017).

Two other rockshelters, now drowned by the Metolong Dam in the eastern (Lesotho) half of the Caledon River corridor, provide further comparative sequences for RCC. One, Ha Makotoko (1640 m a.s.l.), has yielded more than 20 AMS radiocarbon dates spanning from *c.* 45 kcalBP to the early Holocene (Mitchell and Arthur, 2014), although dates are sparsely distributed in the earlier part of its sequence. The other, Ntloana Tšoana, lying only 2 km away, records occupation from *c.* 16 kcalBP through to the recent Holocene with a series of 17 conventional and AMS radiocarbon dates (Mitchell, 1993; Mitchell and Arthur, 2014), although OSL dates for underlying deposits where charcoal did not preserve indicate MSA occupations reaching back to >50 ka (Jacobs et al., 2008). The two sites contain similar archaeological sequences, with MSA material overlain by terminal Pleistocene microlithic Robberg assemblages, followed by more intensive occupations, featuring macrolithic Oakhurst material, during the early Holocene.

Finally, the combined depositional sequences of the adjacent rockshelters, Strathalan A and Strathalan B, on the eastern side of the uKhahlamba-Drakensberg Escarpment in South Africa's Eastern Cape Province at *c.* 1350 m a.s.l., preserve evidence of MSA occupation just prior to MIS 2, plus archaeological material spanning the Holocene, although only 12 conventional radiocarbon dates are available for the two sequences together (Opperman, 1996a, 1996b; Opperman and Heydenrych, 1990). Taken together, these sites can be conceived as being situated at different points along an environmental gradient, from higher rainfall foothill (Strathalan) and mountain country (Sehonghong) in the east to drier, more continental tablelands to the west (Rose Cottage Cave, Ha Makotoko, Ntloana Tšoana). Other sites in this region contain deposits dated to either before or after the LGM, but few have either adequate numbers of dates or a sufficiently complete archaeological sequence to robustly reconstruct occupational histories over the period of interest here (e.g. Kaplan, 1990; Stewart et al., 2012).

1.3 Hypothesized links between palaeoenvironments and lithic technology

Based on the environmental patterning described earlier, Stewart et al. (2012, 2016) have developed a dual-source "push-pull" model of prehistoric landscape occupation for our study area, which proposes that the highlands would have been most suitable for occupation during periods when the climate in southeastern Africa was either relatively dry, unstable or warm. They note that sites in the Maloti-Drakensberg uplands are often situated within the valleys of perennial river systems that originate at high altitudes. Under conditions of regional drying or instability, people living in less well-watered regions, i.e. west of the Escarpment into the central interior of South Africa, are predicted to have moved eastwards into the upper catchments of rivers such as the Orange-Senqu, which would have continued to receive orographic rainfall. During periods of increased regional temperatures, winter conditions at higher altitudes that otherwise limit year-round occupation would have ameliorated, drawing people up into the highlands for more of the year. During especially cold climatic conditions, such as the LGM, people likely abandoned the highlands altogether (Mitchell, 1995; Pargeter et al., 2017; Stewart and Mitchell 2018a; Stewart et al., 2012, 2016). In contrast, the effects of cold conditions on occupation east and west of the highlands were likely mediated by humidity, with cool, humid phases encouraging occupation in both regions. Warmer periods were probably generally conducive to population growth east of the Escarpment and to a more consistent set of site occupations there. Stewart and colleagues stress that these expectations relate to long-term population adjustments rather than shorter-term (e.g. seasonal) movements, which are often archaeologically intractable (Humphreys 1987).

Here, we assess these expectations on a more granular level by generating and testing corollary predictions for hunter-gatherer adaptive processes, specifically shifts in mobility, raw material provisioning, and lithic technology. The close proximity within the Maloti-Drakensberg region of environmental zones with such distinct hydrological characteristics, temperature regimes, and ecological structures likely placed strong selective pressures on hunter-gatherer societies, especially during the climatically variable late Pleistocene. Unfortunately, none of Africa's ethnographic archives describe hunter-gatherers living in such conditions (Stewart and Mitchell, 2018b). For more detailed insights into these adaptations, it is therefore necessary to approach the region's rich archaeological record armed with expectations derived from wider behavioural theory. Hunter-gatherers must obtain subsistence and lithic raw material resources in environments where they are usually unevenly distributed either because of ecological/geological variability or seasonality (Kelly, 2013). To overcome these challenges, groups vary their subsistence practices, provisioning systems, and mobility strategies (Binford, 1980). Provisioning, which some archaeologists define as the systems by which stone artefact technologies are delivered in anticipation of future needs, has been argued to mediate the response of mobility to environmental uncertainty (Mackay et al., 2014). Increased mobility heightens raw material and equipment's transport costs. One could assume that highly mobile foragers would want to provision individuals with light-weight transported goods that maximize utility while less mobile groups would aim to provision places with raw materials and to maximize toolkit functionality (Kuhn, 1994; Nelson, 1991; Shott, 1986).

Archaeologists rely on the nature of an archaeological site's occupation debris and the structure of its lithic assemblages to reconstruct hunter-gatherer mobility and provisioning strategies (Mackay, 2009) (see Table 1). The term 'mobility' as it applies to ethnographically documented hunter-gatherer societies is something of a catchall that encapsulates several (often interdependent) variables, namely the number of residential moves a group makes in a year, the average distance of these moves, the total distance covered, the total area used, and the average length of non-residential extractive (or 'logistical') trips (Kelly, 2013:85). However, teasing these different dimensions of mobility from archaeological palimpsests is effectively impossible, obliging archaeologists to search instead for proxy measures of relative degree of residential mobility. Relatively more mobile foragers emphasize strategies designed to provide individuals with equipment and raw materials necessary to carry out tasks and maintain higher levels of mobility (Kuhn, 1995). Sites occupied by more mobile foragers should show lower artefact discard and greater artefact retouch rates as mobile groups maximize resources carried with them from residential bases (Barton and Riel-Salvatore, 2014). In more stone-rich areas, such as those characteristic of our study area, mobile toolmakers are expected to direct core technology toward making flakes with increased utility, rather than toward increasing the transportability of cores themselves (Kuhn, 1994). Place-provisioning strategies emphasize higher rates of on-site lithic reduction and discard, and less curated (retouched) toolkits (Clark and Barton, 2017). Distinguishing more mobile from less mobile strategies is obviously complicated by 'site type'. Because all of our study sites are large, conspicuous and artefactually dense rockshelters, we are able to control to some degree for the types of locations at which humans would have congregated. Longer-term camps are expected to show lower artefact retouch rates because people do not have to resharpen flakes to maximize their utility. Toolmakers could instead adjust core reduction strategies and replace dulled edges to achieve greater production efficiency. Retouched tool frequencies might also be drowned out by increased lithic discard in these more intensive base camp occupations (Tryon and Faith, 2016).

Table 1 Generalized expectations for stone tool assemblages under opposing hunter-gatherer provisioning strategies.

Provisioning individuals	Provisioning places
Lower artefact discard rates	Higher artefact discard rates
Lower core to retouched tool ratios	Higher core to retouched tool ratios
Higher flake retouch	Lower flake retouch

What expectations can we make about the degree of mobility practised by hunter-gatherer groups living in the three primary ecological zones — the eastern foothills, eastern highlands and western tablelands — crossed by our biogeographical transect given their palaeoenvironmental histories and hypothesized population dynamics? Using radiocarbon ages as measures of site occupation in combination with various measures of lithic technology sensitive to mobility and provisioning, we interrogate RCC and the other sites along our transect for changes they exhibit across three broad occupational phases: pre-LGM (>24 ka), the LGM (24-17.5 ka) and post-LGM (17-10 ka), the last of which incorporates the Pleistocene-Holocene transition.

The early millennia of the pre-LGM period (final MIS 3; 35–30 ka) witnessed relatively high rainfall and low temperatures and evapotranspiration across the Maloti-Drakensberg (Stewart and Mitchell, 2018a). Such conditions were clearly conducive to human settlement since occupation is registered across much of the region at this time (Stewart and Mitchell, 2018a), including in our three ecological zones. We anticipate that these early pre-LGM conditions engendered high levels of hunter-gatherer mobility, particularly in the eastern highlands where average temperatures were consistently ~5°C below present-day (Loftus et al., 2015). However, the pre-LGM period was also one of considerable climatic flux, and longer distance population dispersals across and beyond the region have been suggested. Specifically, drier or more volatile phases are hypothesized to have pushed human populations living in the western tablelands eastwards into the relatively well-watered and resourced Lesotho highlands (and possibly even further east) (Stewart et al., 2012, 2016). Demographic shifts such as these may have amplified as hunter-gatherers responded to reconfigurations of terrestrial environments in the immediate lead-up to (30–25 ka) – and particularly during – the LGM (24–17.5 ka).

The onset of the LGM at 24 ka saw reduced rainfall and intense cold grip interior parts of the summer rainfall region. In the Caledon Valley area, enhanced resource patchiness likely led to reduced site occupation and further increases in residential mobility, as hunter-gatherer groups were obliged to move further and/or more regularly to meet their subsistence needs and maintain contacts with neighbouring groups. In the highlands themselves, we predict the LGM situation was different. There, lowered vegetation belts and snowlines, perhaps coupled with increased numbers of people from in-migration, are anticipated to have linearly packed populations along deeply incised river corridors (Stewart and Mitchell, 2018a). With limited options to move, highland groups are expected to have instead become more residentially stable, an adaptation made possible by intensifying their resource base to include greater quantities of riverine fish (Stewart and Mitchell, 2018b).

As the climate began to warm and stabilize somewhat in the immediately post-LGM period, we anticipate that pressure on mobility lessened in the Caledon Valley with concomitant increases in site occupation intensity. Conversely, sites in the highlands should exhibit higher mobility as alpine vegetation belts and snowlines ascended, allowing populations to fan out and exploit larger expanses of the now more productive mountain landscape. Warming and wetting ramped up during this post-LGM phase, but so too did climatic variability. As noted above, rapid, high-amplitude swings of both temperature and humidity are registered in multiple proxy archives in the region. To counteract the greater stochasticity in resource availability that would have resulted, hunter-gatherer groups throughout the Maloti-Drakensberg would, we suggest, have found themselves under considerable pressure to adopt higher levels of mobility.

Thus, we anticipate that evidence for regional occupation (here radiocarbon dates) and levels of mobility and provisioning (here indices of stone artefact production) will show contrasting, and sometimes complementary, patterns across this marked environmental gradient. Before the LGM, we expect to observe dated occupations throughout the region, with highly mobile groups across the escarpment. During the LGM itself, and in the immediate lead up to it as conditions deteriorated, we expect to see a shift in occupation away from the western tablelands towards the highlands, with a decline in mobility indices as populations were increasingly constrained to the riverine corridors. Subsequently, after the LGM, we expect to see radiocarbon evidence for a re-peopling of the western tablelands with reduced mobility lithic indicators here, contrasting with evidence for higher mobility in the mountains.

2. RCC excavation and dating history

Rose Cottage Cave has a long history of investigation, beginning with extensive excavations through some 6 m of sediments in the 1940s by B.D. Malan (1952). Malan observed two thick Stone Age levels, which he referred to as “Wilton” and “pre-Wilton”, underlain by a couple of metres of largely sterile sand with sparse “microlithic MSA” artefacts, and finally several layers of MSA material above bedrock. However, this excavation produced no radiocarbon dates, and Malan published only a highly schematic stratigraphy. An adjacent section excavated in 1962 by Peter Beaumont largely confirmed Malan’s interpretation, although Beaumont described the assemblage within the sterile yellow sands as “early Later Stone Age”, an industry he had previously recognised at Border Cave (Beaumont, 1978). Material from Beaumont’s excavation was submitted for radiocarbon dating to John Vogel at firstly the Groningen laboratory (Vogel, 1970) and then the newly established Pretoria facility (Vogel and Marais, 1971). These ages helped to outline southern Africa’s Stone Age chronology, establishing for the first time that the LSA extended back in time to *c.* 24 ka, much earlier than previously thought (Vogel and Marais, 1971). Karl Butzer subsequently returned to the site in 1977 to extract sediment and charcoal samples from the Malan excavation profile for three further radiocarbon dates (Butzer and Vogel, 1979). However, the most detailed and well-described excavations at the site were overseen by Lyn Wadley (1997) from 1987 to 1997, with her key goals being those of improving the site’s chronology and reconstructing changing local environments through time (Wadley, 1997).

2.1 Stratigraphy

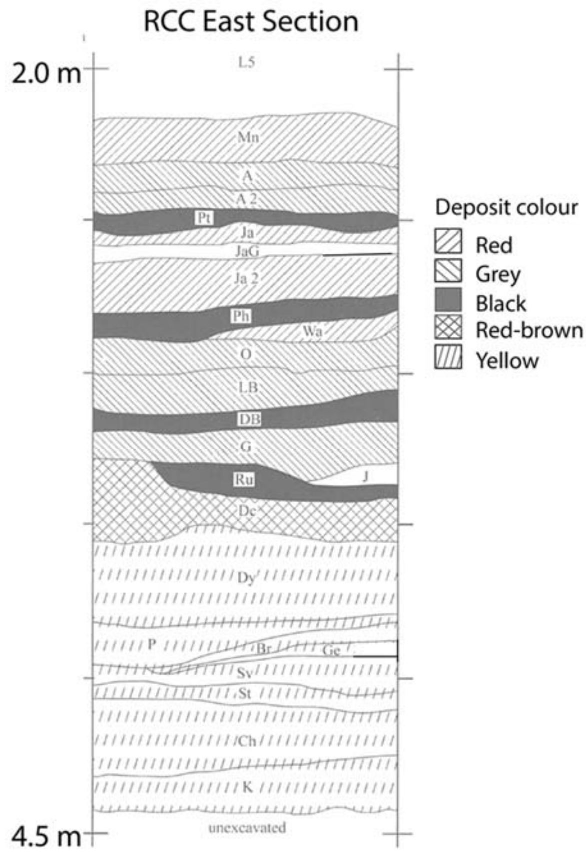

Figure 2 Stratigraphic section of the Rose Cottage Cave deposits, indicating the main levels discussed (adapted from Wadley 1997).

The MSA levels at RCC were excavated across an 8 m^2 area below a depth of *c.* 4.5 m, recording a complex stratigraphy with numerous occupation and sterile sand layers (see Figure 2). From bedrock, some 2 m of occupational deposits were recorded, starting with near-sterile pre-Howieson's Poort levels through a sequence of thin, dark, densely packed Howieson's Poort units (Soriano et al., 2007). These are overlain by several thick layers of orange-brown deposits with comparatively low find densities that conclude with the undated MSA level KAR (Harper, 1997). KAR (unit K in Wadley's (1997) stratigraphy) is overlain by level Ch and several more units of stratified yellow sands through to Level Dy excavated by Wadley across a 32 m^2 area. These yellow sands underlie fine black sediments in level Ru, which Wadley (1997) considered to be the final MSA level at RCC, and which has been dated with three conventional ages to before *c.* 30 kcalBP (Pta-7126: 27700 ± 480 BP, Pta-6202: 27800 ± 1700 BP, Pta-718: 28800 ± 450 BP; see Table 3). Ru is overlain by level J, dated to 26900 ± 550 BP (Pta-6303).

Above Ru, the grey sands of levels G and G2 (now considered to be the same, Lyn Wadley pers. comm., May 21st 2018) contain an "amorphous" stone tool assemblage that is argued to be transitional between the MSA and LSA, with few formal tools ('knives', scrapers, backed tools), irregular flakes, and a predominant use of coarse-grained rocks (Clark, 1999b). These levels were dated by three conventional radiocarbon ages to between *c.* 25-20 kcalBP (Pta-7390: 17800 ± 180 BP, Pta-7289: 19600 ± 220 BP, Pta-5598: 20600 ± 250 BP). Also present and relatively common are ‘irregular’ cores and unretouched bladelets from freehand and bipolar bladelet cores, which Clark (1999a) refers to as ‘microliths’. The lithic artefacts in levels G, G2, and Ru initiate a trend in lithic miniaturization that characterizes the earlier LSA assemblages at the site (Clark, 1997b). Between level G and the subsequent levels, DB, DCM, and LB, a large rockfall is reported to have covered much of the 32 m^2 excavation area, with several lenses containing informal miniaturized assemblages made on small flakes and bladelets, although this event is not evident in the published section drawings (Clark, 1999a). Levels DB, DCM, and LB contain an assemblage made on fine-grained raw materials and characterized by parallel-sided bladelets and single-platform freehand cores, although radiocarbon dates from DB (Pta-5593: 12690 ± 120 BP, Pta-5601: 13360 ± 150 BP) and LB (Pta-7228: 9340 ± 80 BP, Pta-7275: 9560 ± 70 BP) indicate that they accumulated at different times. Wadley (1991) referred to this assemblage as belonging to the Robberg, a widespread late Pleistocene technocomplex characterized by bladelet production (Lombard et al., 2012), and Clark (1997a) argued that its technological origins lay in the site’s MSA levels. These assemblages are succeeded by sedimentary units O, H, Ph, and Ja, which feature lithic assemblages comprising larger side-struck flakes and scrapers on coarse-grained raw materials that Wadley (2000a) designated as Oakhurst, an early Holocene large flake-based technocomplex (Lombard et al., 2012). Several conventional radiocarbon ages date these levels to between *c.* 11 and 8 kcalBP (see Table 3). These occurrences are followed by backed tool, end scraper, and backed bladelet-rich assemblages assigned to the widely occurring Wilton technocomplex (Lombard et al., 2012), found in the dark, organic rich sediments of level Pt that are dated to *c.* 8–6.5 kcalBP (Wadley, 2000b). Finally, post-classic Wilton toolkits, dated to *c.* 2.5–1 kcalBP and comprising tanged arrowheads, bone hooks, small (< 20 mm) scrapers, and adzes are found in the grey ashy levels A2 and A and the brown sands of surface level Mn (Wadley, 1997). European and Iron Age artefacts in Mn and A attest to the site’s continuing use as late as the early nineteenth century (Behrens, 1992; Wadley, 1992).

3. Methods and sample selection

3.1 Sample selection

The radiocarbon dating reported here aimed to clarify the chronology across the MIS 3 and MIS 2 levels of RCC that were previously undated, or those where the existing dates conflicted in some way with the sequence, in order to improve comparability with our other dated sites of interest. Our sampling focused on curated charcoals from Wadley’s excavations at the site. We selected two samples from MSA levels K and Ch, both previously undated, which lie at the base of Wadley’s excavations. One sample was also selected from level Ru as the existing three ages for this level all had quite broad errors. Another was selected for the overlying level J, previously dated at the J/Ru contact by only one conventional date. Levels G and G2 were previously dated by three conventional ages, but the late age of *c.* 18 kBP for the early LSA assemblages in level G, in particular, warranted confirmation, as by this time Robberg-like assemblages are evident at other sites in the region (Mitchell, 1995; Pargeter et al., 2017; Stewart et al., 2012). One further sample was selected from both LB and DB, to confirm what — by comparison to many other parts of southern Africa — are somewhat young ages for the Robberg assemblages in these levels, especially level LB (Wadley, 1996, 2000).

3.2 Radiocarbon dating

Charcoal samples were selected from the RCC collections housed at the Archaeology Department of the University of the Witwatersrand (South African Heritage Resources Agency export permit 2447). Twig-like fragments were preferentially selected to avoid potential “old wood” effects that might lead to ages greater than the archaeological event, although this is not considered to be problematic over these timescales in this region. Intact samples were selected to avoid accidentally sampling different charcoals. No chemicals had been applied to the samples as part of conservation efforts. Samples were prepared in the University of Oxford's Research Laboratory for Archaeology and the History of Art (RLAHA) Radiocarbon Unit. Two different pretreatment protocols were applied to the samples: the standard acid-base-acid (ABA) pretreatment for charcoal (Brock et al., 2010), and the more rigorous acid-oxidation stepped combustion (AOx-SC) method for those charcoals predicted to be older than *c.* 20 ka. This protocol is a modified procedure of the ABOx-SC protocol (Bird et al., 1999; Brock et al., 2010) that omits the base wash and is being developed for dating old and fragile charcoal samples (Douka *et al.* in prep.), but it produces similar effects to the ABOx-SC protocol.

3.3 Calibration and Kernel Density Estimation modelling

The new AMS and previously published radiocarbon measurements were calibrated with the OxCal v 4.2 software (Bronk Ramsey, 2009), using the latest SHCal13 calibration curve for the Southern Hemisphere (Hogg et al., 2013). The RCC dates were modelled according to Bayesian statistical principles in OxCal, using stratigraphic information from Wadley's excavations, in a *Sequence* model with stratigraphic levels represented as *Phases*, separated by a single or double *Boundary*.

Table 2 Archaeological sites with radiocarbon chronologies modelled in this study (see map in Figure 1C). The numbers of dates available for the entire occupational sequence and those considered reliable for inclusion in a site model (i.e. with known stratigraphic provenience, in sequence, etc.) are also indicated.

Site name	Site code	Dec. °S	Dec. °E	Country	Province/ District	Total dates	Modelled dates
Strathalan A and B	STA/STB	-30.983	28.383	South Africa	Eastern Cape	13	12
Sehonghong	SEH	-29.750	28.750	Lesotho	Thaba Tseka	57	55
Ha Makotoko	HM	-29.333	27.800	Lesotho	Maseru	26	20
Ntloana Tšoana	NT	-29.317	27.817	Lesotho	Maseru	23	21
Rose Cottage Cave	RCC	-29.250	27.500	South Africa	Free State	50*	33*
Total						169	141

* *Including new AMS ages*

To compare RCC's occupational sequence with the wider region, five sites with both sufficient numbers of radiocarbon measurements and adequately preserved and described stratigraphic detail across the late Pleistocene and through to the Pleistocene/Holocene transition were individually modelled to provide long sequence comparisons (Table 2). They are Sehonghong, Ntloana Tšoana, Ha Makotoko, and Strathalan A and B (the last two treated as a single sequence). Dates are recorded in the new online database for southern African radiocarbon dates (https://c14.arch.ox.ac.uk/sadb; Loftus et al., in press). Dates are summarized using a Kernel Density Estimation (KDE) approach developed for OxCal (Bronk Ramsey, 2017), which averages numerous Markov Chain Monte Carlo simulations of the underlying distribution of a collection of calibrated radiocarbon probability density functions. This is a more appropriate method than the straightforward summing of dates and presents a smoothed distribution that does not overemphasize potentially false peaks, and which can be more helpfully interpreted for the distribution of radiocarbon dates, a proxy for site occupation. The implementation in OxCal integrates the frequentist KDE method with established Bayesian modelling methods that facilitate the incorporation of stratigraphic information and other prior information, allowing KDE models to be constrained in various ways (Bronk Ramsey, 2017).

3.4 Lithic comparisons

Radiocarbon dates provide one way for archaeologists to examine site and regional occupation variability. Stone artefacts provide another durable and independent line of evidence to examine patterning in regional occupation patterns, provisioning strategies, and technological organization. Humans occupying different sites at the same point in time may not have done so in the same manner and variations in these dimensions provide important insights into human behavioural variability at landscape scales. Fortunately for our purposes, the five key sites listed above already have lithic data recorded using J. Deacon's (1984) standardized lithic inventory system. These data allow us to compare the following three lithic variables across the sites: core to retouched tool ratios, retouched tool frequencies, and lithic discard intensities. We explore the lithic data through the three phases, pre-LGM, LGM, and post-LGM, mentioned above.

The three lithic variables enable us to test expectations derived from theoretical and ethnographic modelling of the effects of mobility and resource scheduling on hunter-gatherer technological organization (see section 1.3 and Table 1). Core to retouched tool ratios provide a measure of the relative transport of lithic reduction potential (cores) as opposed to tools (flakes), while retouched tool frequencies provide a relative measure of toolkit curation (Barton and Riel-Salvatore, 2014; Kuhn and Clark, 2015). Mackay (2009) argues that higher core to retouched tool ratios indicate more mobile groups and provisioning of individuals, while Barton and Riel-Salvatore (2014) argue that greater retouched tool frequencies signal increased mobility. Retouched tool frequencies are presented separately to test Barton and Riel-Salvatore's (2014) hypothesis. We calculated lithic discard intensity using the ratio of total lithic artefacts recovered to the age range for each assemblage. We derived age ranges from each site's radiocarbon model outputs (SOM Table 1).

These data provide a broad framework against which to assess patterning in our radiocarbon dates and the relationships hypothesized to exist between hunter-gatherer provisioning, mobility, and lithic technology (Table 1). All the assemblages presented in this analysis were made predominantly, if not exclusively, on local rocks and all except Strathalan B (made on hornfels) were reduced from cryptocrystalline silicate nodules (i.e. chert, agate, and chalcedony). Ntloana Tšoana's crystal quartz sub-assemblage has been removed from this analysis to ensure comparability with the remaining sites (Pargeter, 2016), and, while there is archaeological material in the pre-LGM levels of Ha Makotoko, the lithic assemblage is yet to be studied. At Ha Makotoko, Ntloana Tšoana, Rose Cottage Cave, and Sehonghong raw materials derive from river-borne nodules or exposures in the lavas of the Lesotho Formation. All the data presented in SOM Table 1 were standardized by each lithic variable's mean to allow for inter-site comparisons. Statistical tests were conducted using permutation methods (Asymptotic General Independence Tests) in the *R* computing environment's *Coin* package (R Core Team, 2013). Asymptotic tests provide a general independence test for sets of variables measured on arbitrary (non-Gaussian) scales (Arnold, 1980). Alpha values were divided by 3 to account for multiple comparisons and interaction effects were tested only for Sehonghong and RCC where data for the three climate phases are available.

4. Results

4.1 AMS radiocarbon dates and site Bayesian model

While the RCC deposits have previously been dated by several researchers (Butzer and Vogel, 1979; Pienaar et al., 2008; Vogel and Beaumont, 1972; Wadley, 1991; Wadley and Vogel, 1991; Woodborne and Vogel, 1997) (see Table 3), the largest set of dates available are radiocarbon dates on charcoal produced at the Pretoria laboratory from Wadley's excavation. These dates reveal a generally coherent and continuous stratigraphy from >50 ka through to recent centuries. Wadley's excavations yielded 28 finite radiocarbon dates in total (Table 3).

Figure 3A shows these radiocarbon dates aggregated using the *Sum* function in OxCal (Bronk Ramsey, 2001). Figure 3B aggregates the same set of 28 dates in OxCal using an unconstrained *KDE_Model* function (Bronk Ramsey, 2017). The *KDE_Model* for all RCC dates reveals peaks in the number of radiocarbon dates centring on *c.* 35 ka and 10 ka, and an apparent decline in archaeological activity (as reflected in the occurrence of radiocarbon dates) across MIS 2. However, the shape of these peaks is very broad, and the marginal posterior distribution of the *g* shaping parameter (inset Figure3B) is not well constrained (an estimate of model fit, the narrower and more normal this distribution, the better the priors describe the posterior KDE distribution. See Figure 20 in Bronk Ramsey, 2017 for a discussion). Moreover, thirty ensembles of 1000 individual Markov chain Monte Carlo simulations (the pale grey unfilled distributions) show considerable variance. Together, these factors suggest that the model does not capture the underlying distribution of radiocarbon dates very well, most likely because the model has too few dates and a lack of stratigraphic constraints.

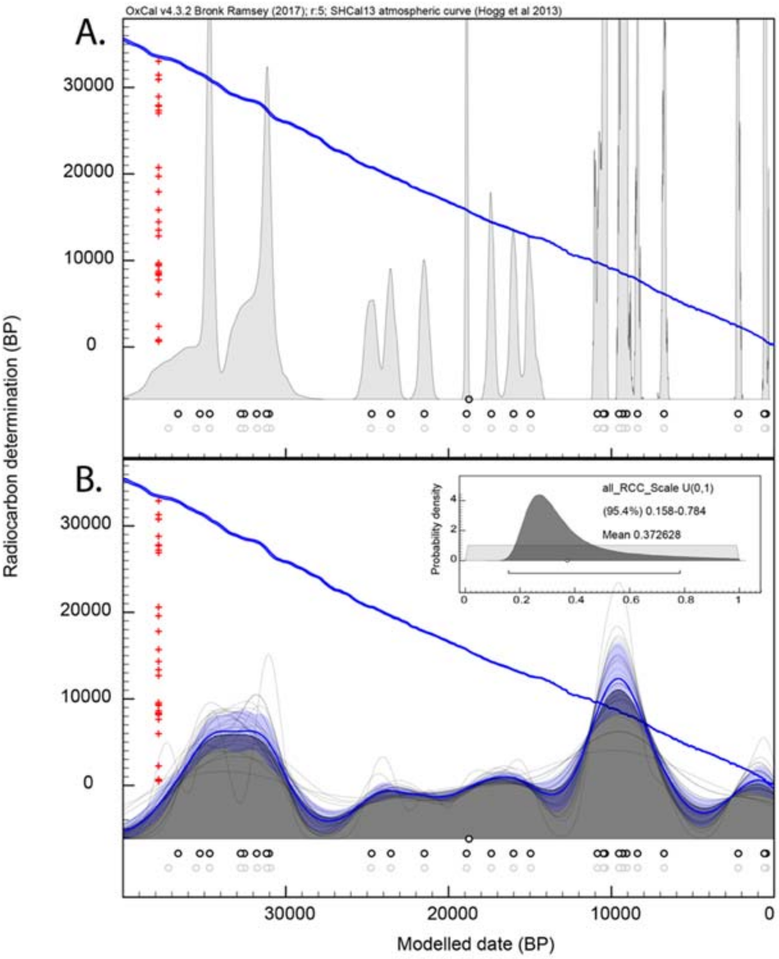

Figure 3 A) Summed probability distribution for 28 radiocarbon dates from Rose Cottage Cave across 40 kcalBP. B) Kernel Density Estimation model for the same set of radiocarbon dates, with thirty Monte Carlo Markov chain ensembles shown and the g shaping factor displayed as an inset. The bold blue line represents the average of the Monte Carlo Markov chain ensembles, with the blue shaded area representing ±1σ around this. The pale grey circles are the medians of the calibrated radiocarbon probability distributions (i.e. the calibrated date range), while the black circles are the medians of the posterior distributions (i.e. the modelled age range) for each dated event (including modelled Boundaries, etc.). The SHCal13 calibration curve is also presented in blue (Hogg et al., 2013).

Table 3 Previously published radiocarbon dates from Rose Cottage Cave, with archaeological associations as suggested by the excavators. Levels are after Wadley (1997), with equivalents in other excavations where described. ELSA: Early Later Stone Age

Excavator	Level (after Wadley 1997)	Material	Laboratory code	Radiocarbon date (BP)	±	Archaeological association	Reference
Wadley	Mn	Potsherd	Pta-6788	500	50	Ceramic LSA	1
Beaumont	= A	Potsherd	Pta-350	610	50	Ceramic LSA	2
Wadley	A	Charcoal	Pta-5622	680	50	Ceramic LSA	3
Beaumont	= A2?	Charcoal	GrN-5298	1100	30	Post-classic Wilton	4
Wadley	A2	Charcoal	Pta-7117	2240	60	Post-classic Wilton	5
Wadley	Pt	Charcoal	Pta-5934	5970	70	Wilton	1
Beaumont	= Pt?	Charcoal	GrN-5299	6850	45	Wilton	4
Wadley	Pt	Charcoal	Pta-6783	7630	80	Wilton	1
Wadley	Ja	Charcoal	Pta-7122	8160	70	Oakhurst	5
Wadley	Ph	Charcoal	Pta-7287	8350	70	Oakhurst	5
Wadley	JaG	Charcoal	Pta-5600	8380	70	Oakhurst	3
Wadley	H	Charcoal	Pta-5560	8614	38	Oakhurst	3
Malan/Butzer		Charcoal	Pta-2076	8640	100		6
Wadley	O	Charcoal	Pta-5599	9250	70	Oakhurst	3
Wadley	LB	Charcoal	Pta-7228	9340	80	Robberg	5
Wadley	LB	Charcoal	Pta-7275	9560	70	Robberg	7
Wadley	DB (top)	Charcoal	Pta-5593	12690	120	Robberg	3
Wadley	DB (bottom)	Charcoal	Pta-5601	13360	150	Robberg	3
Wadley	Be	Charcoal	Pta-7290	14320	120	Robberg	5
Wadley	Wal	Charcoal	Pta-6195	15700	40	Robberg	1
Wadley	G	Charcoal	Pta-7390	17800	180	ELSA	8
Wadley	G/G2	Charcoal	Pta-7289	19600	220	ELSA	5
Wadley	G/G2	Charcoal	Pta-5598	20600	250	ELSA	3
Malan/Butzer	Orange Sand	Charcoal	Pta-1416	22700	240	ELSA	6
Malan/Butzer	Orange Sand	Charcoal	Pta-1417	23400	200	ELSA	6
Beaumont	Jf? "ELSA"	Charcoal	GrN-5300	25640	220	ELSA	9
Wadley	J/RU	Charcoal	Pta-6303	26900	550	ELSA	1
Wadley	Dc	Charcoal	Pta-5596	27200	350	Final MSA	3
Wadley	Ru	Charcoal	Pta-7126	27700	480	Final MSA	7
Wadley	Ru	Charcoal	Pta-6202	27800	1700	Final MSA	1
Wadley	Ru	Charcoal	Pta-7184	28800	450	Final MSA	7
Beaumont		Charcoal	Pta-0211	29430	520	ELSA	9
Wadley	Dy/Orange Sand	Charcoal	Pta-7805	30800	200	MSA	8
Wadley	Orange Sand	Charcoal	Pta-7763	30800	200	MSA	8
Wadley	Ge/Orange Sand	Charcoal	Pta-5592	31300	900	MSA	3
Wadley	Orange Sand	Charcoal	Pta-7796	32900	910	MSA	8
Beaumont		Charcoal	Pta-0001	36100	2000	MSA	2
Beaumont		Charcoal	Pta-0354	>40950		MSA	9
Beaumont		Charcoal	Pta-0214	>42500		MSA	9
Beaumont		Charcoal	SR-0116	>48000		MSA	9
Beaumont		Charcoal	Pta-0231	>48400		MSA	9
Beaumont		Charcoal	Pta-0213	>50200		MSA	9

References:
1 Wadley (1995); 2 Vogel and Marais (1971); 3 Wadley and Vogel (1991); 4 Vogel (1970); 5 Clark (1997b); 6 Butzer and Vogel (1979); 7 Woodborne and Vogel (1997); 8 Pienaar et al. (2008); 9 Beaumont and Vogel (1972).

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Table 4 AMS ages of charcoals from Rose Cottage Cave, with calibrated age ranges at 2σ, rounded outwards to 5 years, using OxCal v. 4.3 and SHCal13 (Hogg et al., 2013). Also provided are the radiocarbon $F^{14}C$ measurements and □^{13}C values. Pretreatment codes: YR – acid-oxidation, stepped combustion; XR – acid-base-oxidation, stepped combustion; ZR - acid-base-acid.

Laboratory code	Pretreat ment	Level	Radiocarbon date (BP)	±	Calibrated age (cal BP)		$F^{14}C$	±	□^{13}C
					from	to			
OxA-35528	XR	LB	9560	40	11085	10605	0.30425	0.0016	-23.8
OxA-35529	ZR	DB	9465	40	10765	10520	0.30782	0.0016	-22.0
OxA-35530	XR	G	26490	180	31040	30355	0.03698	0.0008	-23.7
OxA-35531	YR	J	30460	240	34835	33965	0.02257	0.0007	-23.1
OxA-36205	YR	Ru	28100	1000	34415	30615	0.03044	0.0039	-23.6
OxA-35856	YR	Ch	30820	290	35310	34135	0.02155	0.0008	-22.4
OxA-35381	YR	Ch	30820	250	35215	34185	0.02157	0.0007	-22.2
OxA-35954	YR	K	42900	1400	49550	44200	0.00481	0.0008	-24.0

Table 4 lists the eight new AMS dates we have obtained for RCC, with their calibrated age ranges, radiocarbon measurements, and $\delta^{13}C$ values. These ages present some significant discrepancies with the existing chronology, which is not unexpected given the improved pretreatment methods now available and employed in this study. The lowermost level, K, yielded a date of 42900 ± 1400 BP, which, once calibrated, extends back to the limits of the radiocarbon calibration curve. Level Ch, for which two ages were obtained on the same charcoal, produced an age that is significantly younger than that for K (30820 ± 290 BP and 30820 ± 250 BP), suggesting a long hiatus of about 10,000 years between the accumulation of these two MSA levels. The published section (Wadley, 1997) suggests that both are quite thick and may therefore represent long periods of occupation interspersed by a lengthy hiatus.

AMS dates from levels J and Ru present an inversion, with the overlying age from J (30460 ± 240 BP) older than that from Ru (28100 ± 1000 BP). Unfortunately, the charcoal from level Ru yielded only a small amount of carbon for dating, resulting in the large error of 1000 years for this date. The AMS date for J is several thousand years older than previous ages for level Ru, but this can be accounted for by the ABOx pretreatment protocol used here, which typically results in older ages for very ancient charcoals. Similarly, the AMS age for level G, 26490 ± 180 BP, is older than previous ages for this level and the underlying level G2, which may be due to the improved pretreatment and smaller sample requirements. However, the AMS age for level DB (9465 ± 40 BP) is several thousand years younger than that indicated by the two previous ages for this level. This discrepancy may be due to the smaller sample requirements of AMS methods (which necessitate less aggregation of charcoal fragments for measurement), or, more likely, the new age may indicate downward movement of small charcoal fragments in this part of the sequence. There is a virtually complete overlap in the calibrated ranges for this age and that from the overlying level LB, 9560 ± 40 BP, which is itself consistent with the previously acquired ages for this level.

To constrain the ages of the separate levels, and those of the technological transitions, we modelled the conventional radiocarbon dates and new AMS ages in an OxCal *Sequence* model. Given the discrepancies between the new and old ages, some conventional ages were omitted from the model as outliers (according to the indices method described in Bronk Ramsey 2009b). Moreover, the ages from J and Ru were modelled together in a single *Phase*, as it appears that these levels accumulated rapidly. Figure 4 shows the full sequence of 33 radiocarbon dates spanning *c.* 45 ka. Below the sequence we show the KDE Model, with individual ages indicated against the calibration curve, providing a visual representation of the clustering of dates across the sequence. The inset figure shows the *g* shaping parameter.

The *Sequence* model indicates two key periods of deposit accumulation, *c.* 35–30 kcalBP and *c.* 11–8 kcalBP. Despite targeted sampling across the MSA/LSA transitional period, there is little indication that the site was occupied after *c.* 30 kcalBP until *c.* 25 kcalBP. Moreover, the conventional dates from level G/G2 between *c.* 25–20 kcalBP are contradicted by the >30 kcalBP AMS date from G, suggesting that the site might have been unoccupied, or occupied only sporadically, across the entire period 30–20 kcalBP. Four radiocarbon dates span the subsequent 5 ka from *c.* 20–15 kcalBP, over levels Wal, Be, and DB. Levels Wal and Be are not well-described in the literature and do not appear on many of the published sections of the site: they seem to be small pockets of sediment that were not observed across the whole extent of the deposits, and may well represent more ephemeral occupations over this period. The earliest Robberg-like assemblages at the site appear *c.* 16 kcalBP in level DB, which is substantially later than elsewhere in the region, such as at Sehonghong (Pargeter et al., 2017).

The second major peak in radiocarbon dates, *c.* 11–8 kcalBP, was a time of marked technological variability between levels LB and O. Approximately half a metre of sediment accumulated across levels LB to Ja, suggesting that the site was relatively intensively occupied during the early Holocene. An occupational hiatus appears to begin *c.* 6 kcalBP, spanning the mid-Holocene until the radiocarbon dates for the post-classic Wilton levels from *c.* 2 kcalBP.

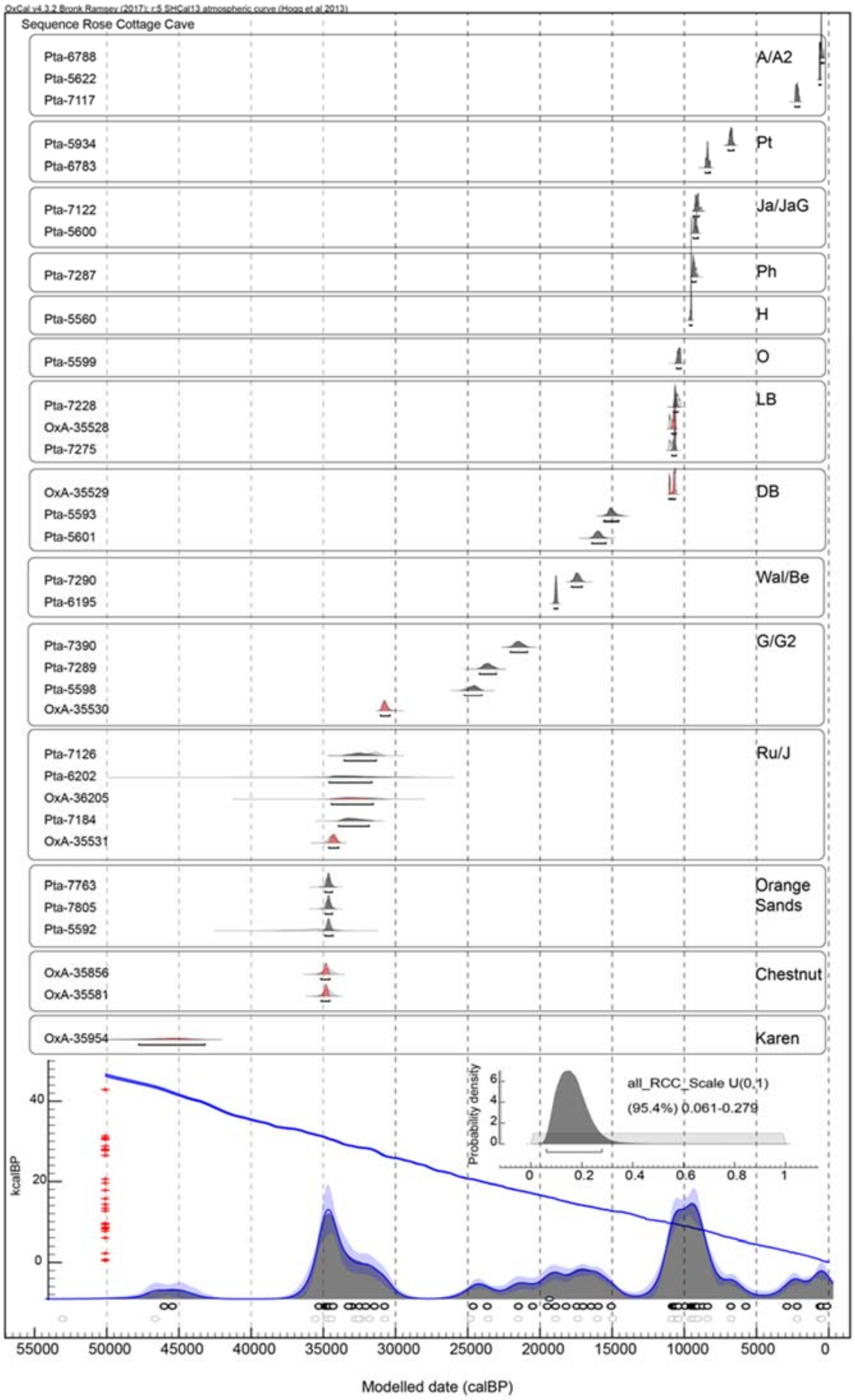

Figure 4 Thirty-three radiocarbon dates from Rose Cottage Cave in the Sequence *Model, with stratigraphic levels as* Phases*, with the KDE model show below (Ramsey 2017), and* g *shaping parameter inset. New AMS age distributions are shown in red. See Figure 3 for interpretation of other figure elements.*

4.2 Chronologies of Rose Cottage Cave and other long archaeological sequences

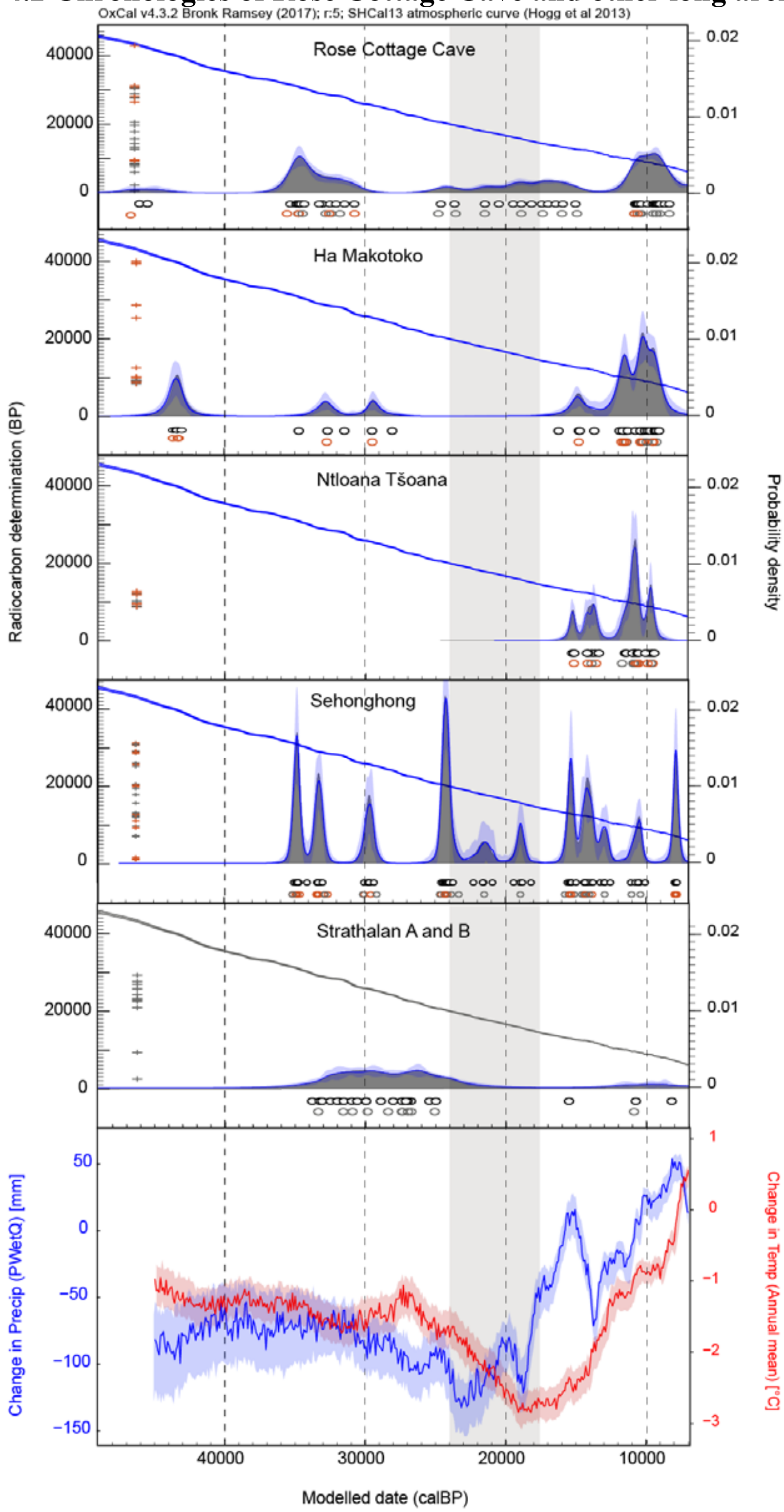

Figure 5 compares the chronological sequences of the five sites within the region, including RCC, that have sufficient numbers of dates and adequately preserved and described stratigraphic sequences across the late Pleistocene. The chronologies presented are based on published radiocarbon dates and stratigraphic information for each site. The figure also presents modelled temperature and regional precipitation changes from Chevalier and Chase (2015).

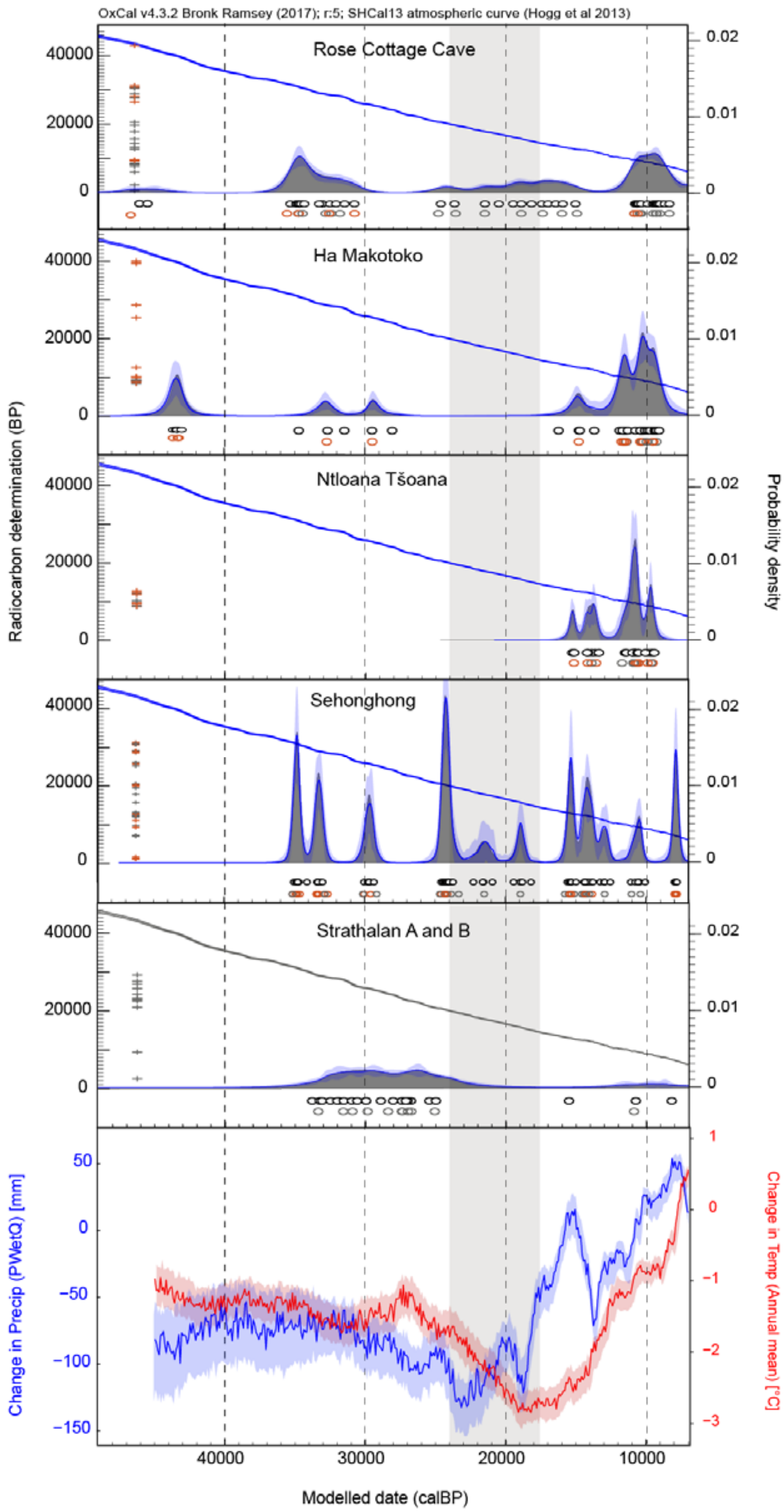

Figure 5 Kernel Density Estimation sequence models for the radiocarbon chronologies of five sites across the Maloti-Drakensberg region. Individual models are based on published stratigraphic sequences at each site (see text and SOM for details). The bottom plot shows pollen-derived models of mean annual temperature (red) and precipitation of the wettest quarter (blue: central and eastern region) changes from Chevalier and Chase, 2015. The LGM (24–17.5 ka) is indicated by the grey shaded box. Red circles and crosses indicate individual AMS ages, while blue crosses indicate conventional dates. See Figure 3 for interpretation of other figure elements.

Radiocarbon dates from Rose Cottage Cave, Ha Makotoko, Strathalan, and Sehonghong all record pre-LGM occupation from *c.* 35 kcalBP, ending *c.* 30 kcalBP at the Caledon Valley sites, but persisting later at both Strathalan and Sehonghong. Comparison of the patterning in the two most continuous sequences, Sehonghong and RCC, shows marked differences. Pronounced peaks in the radiocarbon KDE model of Sehonghong contrast with the more undulating distribution of Rose Cottage Cave, suggesting that occupation at the former was confined to brief episodes separated by hiatuses, whereas depositional phases at RCC span longer periods of time. While caution is warranted when comparing site distributions that are based on different numbers of dates (Sehonghong generally has more dates per stratigraphic unit than RCC), examination of the spread of dates at each site does reveal tighter clustering of dates within the separate stratigraphic units at Sehonghong than at RCC. The Strathalan sequence features a long hiatus after *c.* 25 kcalBP, while the Sehonghong sequence continues to show short pulses of occupation, with only brief hiatuses during the height of the LGM. Rose Cottage Cave also preserves material from *c.* 25–17 kcalBP but, as discussed above, several of these conventional radiocarbon dates may in fact under-represent the age of these deposits and therefore overemphasize the degree of continuity in this part of the sequence. Certainly, across all five sites, MIS 2 and the LGM seem to have been a time at which sites were either unoccupied or occupied only ephemerally. The three sites within the Caledon Valley — RCC, Ha Makotoko, and Ntloana Tšoana — indicate a peak in occupation centring on *c.* 10 kcalBP, perhaps beginning slightly earlier in Lesotho than at RCC. Only a single radiocarbon date is reported for Strathalan A over this period, although as it dates the bottom of the depositional sequence at this site this may not be representative of occupation intensity at the site. Sehonghong also records archaeological activity across the terminal Pleistocene and early Holocene, but here the KDE once again indicates a more punctuated depositional sequence.

4.3 Comparisons of the lithic evidence

The three lithic technological variables depicted in Figure 6 (data summarized in Table S1, SOM) show marked diachronic and synchronic differences between the five sites. For each of the three lithic variables, we test for the effects of site differences, differences across climate phases, and the interaction between sites and climate phases.

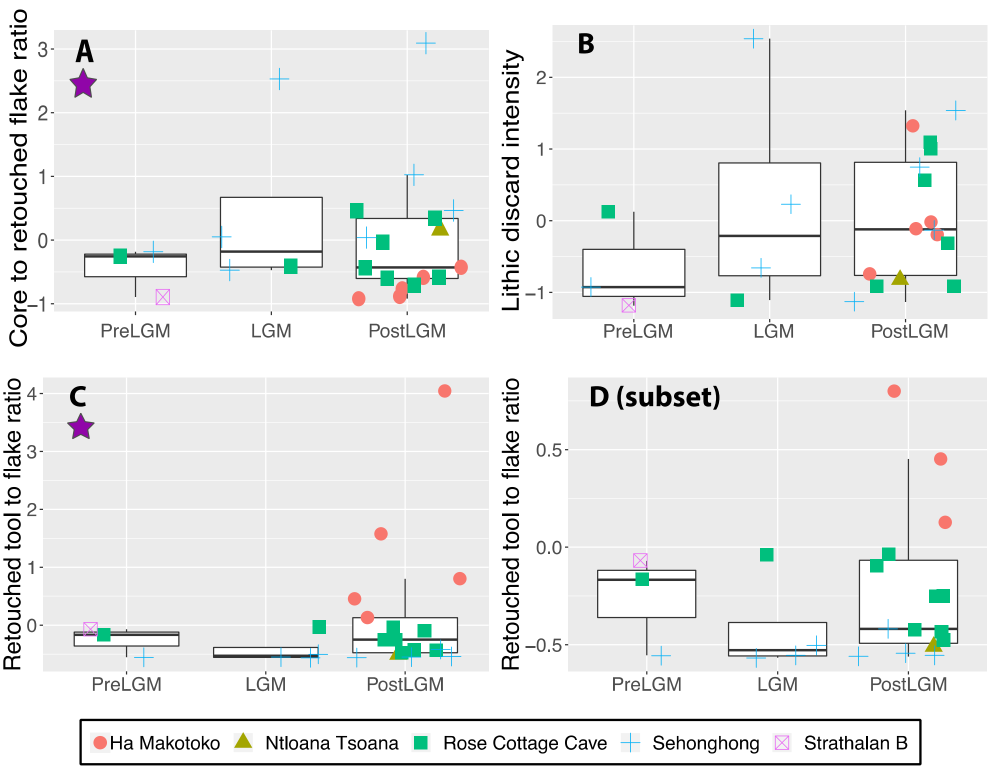

Figure 6 Lithic variables compared with three phase climate intervals for the five comparison sites. Statistically significant effects of site differences, using permutation methods and the Asymptotic General Independence Test, are indicated by a purple star. Plot D depicts a subset of plot C with y-axis values truncated at 1. Jittered data points are arranged according to variable values and their position does not reflect age.

Core to retouched tool ratios are generally lower during the pre-LGM and post-LGM with marginal increases during the LGM (Figure 6A). Strathalan B's core to retouched tool ratios are lower than the other pre-LGM assemblages while Sehonghong's LGM pattern shows considerable variability. The post-LGM pattern is tightly clustered, with RCC's data showing similarities with both Sehonghong and Ha Makotoko on the lower end of the scale. Once again, the Sehonghong data show markedly higher post-LGM core to retouched tool ratios. Statistical tests show a significant effect of site differences (maxT=2.9, df=4, adjusted p=0.01) (see Table 5). Tests show no significant effect of climate phase and site:climate phase interaction at the alpha=0.01 level.

Table 5. Statistical comparisons of lithic evidence from the five study sites and climate phases. Test statistics were generated with permutation methods using the Asymptotic General Independence Test. Adjusted alpha level values are given for three comparisons per variable.

Variable	Factor	Test statistic	Df	p-value	Adjusted alpha
Retouched tool ratio	Site	3.5	4	**<0.01**	**0.01**
	Climate phase	2.3	2	0.04	
	Site:climate phase	2.6	4	0.04	
Core to retouched ratio	Site	2.9	4	**0.01**	
	Climate phase	1.3	2	0.35	
	Site:climate phase	2	4	0.18	
Lithic discard intensity	Site	1.2	4	0.66	
	Climate phase	1.7	2	0.19	
	Site:climate phase	1	4	0.76	

Lithic discard intensities, reflecting the per unit time lithic depositional rates, show similar patterning to the core to retouched tool ratio (Figure 6B). The pre-LGM values are generally low with upticks in the LGM and similar values during the post-LGM. The RCC pattern shows high pre-LGM values with dips during the LGM and upticks in intensity during the post-LGM period. Sehonghong shows widely variable discard intensity values reflecting patterns in the site's radiocarbon dates (Figure 5). All four sites show widely variable discard intensity patterns during the post-LGM period. None of the statistical tests showed significant differences.

Table 6. Statistical comparisons of lithic evidence from the three topographic groups and climate phases. Test statistics were generated with permutation methods using the Asymptotic General Independence Test. Adjusted alpha level values are given for three comparisons per variable.

Variable	Factor	Test statistic	Df	p-value	Adjusted alpha
Retouched tool ratio	Elevation	2.8	1	**<0.02**	**0.02**
	Elevation:climate phase	2.5	5	0.06	
Core to retouched ratio	Elevation	2.9	1	**<0.02**	
	Elevation:climate phase	2.4	5	0.08	
Lithic discard intensity	Elevation	0.9	1	0.33	
	Elevation:climate phase	1.3	5	0.67	

Overall, retouched tools show a parabolic trend through time with high pre-LGM levels followed by a sharp dip during the LGM and a subsequent increase during the post-LGM (Figure 6C). Sehonghong's retouched tool frequencies remain relatively stable across the three phases with the site's retouched tool values converging on those at Ntloana Tšoana and RCC during the post-LGM. Ha Makotoko's post-LGM retouched tool values are markedly higher than the other three sites. Both RCC and Ha Makotoko show widely spread post-LGM retouched tool frequencies. General independence permutation tests show an effect of site differences (maxT=3.5, df=4, adjusted p <0.01). Neither climate phase nor the interaction between site and climate phase showed significant differences at the adjusted alpha=0.01 level.

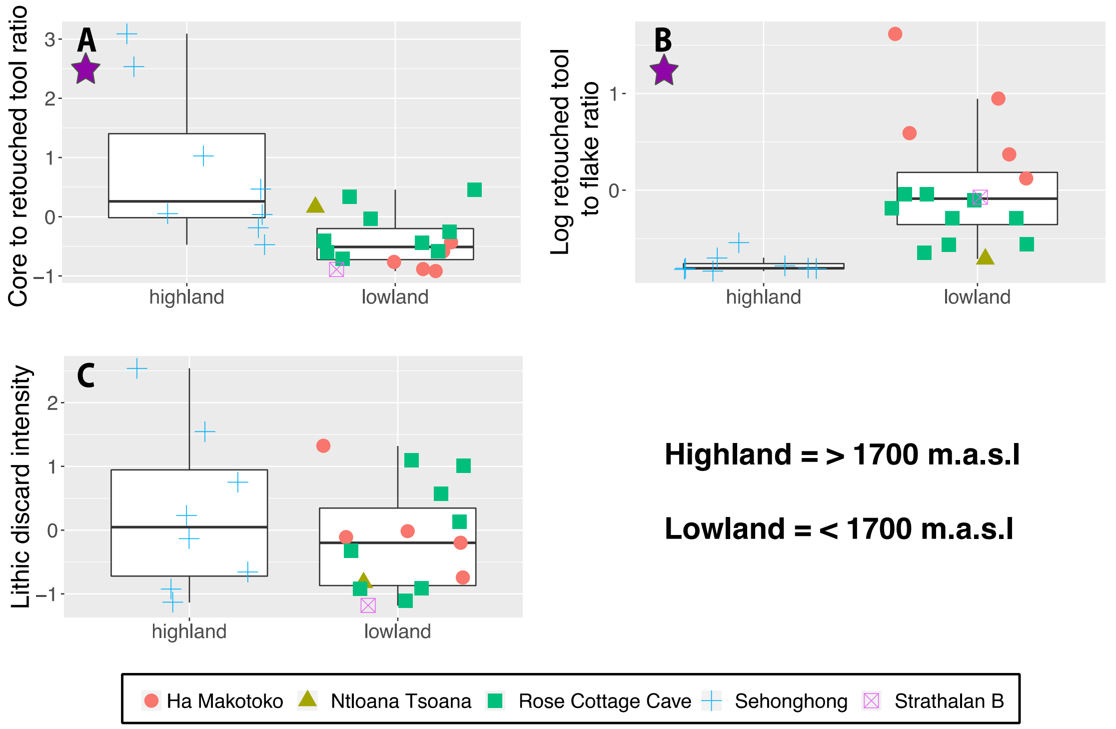

Figure 7 Lithic variables compared between highland (>1700 m a.s.l) and lowland (<1700 m a.s.l) locations. The purple star indicates a statistically significant effect of elevation differences using permutation methods and the Asymptotic General Independence Test.

Figure 7 shows comparisons of the three lithic variables across two broad elevation groupings (< and > 1700 m a.sl). The results show marked differences between our higher elevation site (Sehonghong) and the lower elevation sites of Ntloana Tšoana, Ha Makotoko, Strathalan B, and RCC. Core to retouched ratios are significantly greater at higher elevations (maxT=2.9, df=1, adjusted p<0.02), while retouched tools show significantly lower values at higher elevations (maxT=2.8, df=1, adjusted p<0.02) (see Table 6). Lithic discard intensities are statistically indistinguishable at higher versus lower elevation sites. Tests of the interaction effect between elevation and climate phases show no significant differences, suggesting that the patterned differences result from elevation differences alone.

5. Discussion and conclusions

Informed by new AMS dates from Rose Cottage Cave, our assessment of chronological and archaeological data provides a new perspective on the complex interaction between palaeoenvironments, landscape structure, mobility, and provisioning strategies in and around the Maloti-Drakensberg Mountains of southern Africa during the late Pleistocene.

5.1 Rose Cottage Cave chronology and technological change

The new AMS ages for levels G, J, and Ru present an intriguing contrast with the previous chronology for the site's final MSA and early LSA levels. Previously, levels Ru and G were dated to *c.* 32 and *c.* 23 kcalBP, respectively (summarized as *c.* 28,000 bp and 20,000 bp by

Clark (1997a, 1999a), without calibration), suggesting a possible hiatus between the two assemblages, or that they accumulated over a long period. However, the three AMS dates for these levels, and indeed also the two dates from the underlying MSA level Ch, cluster within a 5 kyr span, from 35–30 kcalBP. This might indicate that the technological shifts observed between level Ru and level G/G2 occurred more rapidly than previously thought (Clark, 1999a, 1997a). Unfortunately, little contextual information about the conventional dates for these levels can be gathered from the published sources that would help with an assessment of this discrepancy. The final MSA and early LSA levels at Sehonghong were deposited at a similar time *c.* 34–30 kcalBP, adding support to the idea of a relatively rapid transition and the operation of region-wide processes in the MSA-LSA transition.

Wadley (1996) argues that later patterns of lithic miniaturization involving bladelet and small flake production that commence *c.* 15 kcalBP at RCC have antecedents in the site's final MSA and early LSA occupations. While it is plausible that such systems were in use by groups with a long-term shared technological repertoire, we also have to acknowledge the more parsimonious hypothesis that the recurrence of bladelet technologies some 10,000 years after their initial appearance represents a case of independent re-invention and technological convergence. This argument is strengthened by the fact that the RCC Howiesons Poort assemblage (dated *c.* 64–55 ka [OSL]) also contains evidence for systematic bladelet production (Soriano et al., 2007). Elsewhere, archaeologists have demonstrated that miniaturized lithic technologies are particularly susceptible to convergent evolution because they are easy to make, have several economic advantages, and can be made on a wide range of rock types (Clarkson et al., 2018). These benefits would have made miniaturized lithic systems attractive to foraging groups occupying a wide range of contexts.

The new AMS date for level LB also confirms the persistence of miniaturized bladelet dominated toolkits at this site for several thousand years after they were replaced by macrolithic stone tools at other sites in the region, including the nearby sites of Ha Makotoko and Ntloana Tšoana (Mitchell, 1993; Mitchell and Arthur, 2014; Mitchell and Pargeter, pers. obs.). Layers LB and DCM are, in fact, contemporaneous and formed rapidly following the deposition of the underlying layer DB. Various possibilities present themselves to explain the persistence of miniaturized technologies here, including the maintenance of distinct social boundaries between RCC and the Lesotho sites (perhaps marked by the Caledon River; Mitchell, 1993); activity differences between the two locales, or perhaps analytical differences in how the assemblages have been sampled and/or characterized.

The lack of evidence for occupation of RCC in the lead-up to the LGM (*c.* 30–25 kcalBP) may be related to dramatically cooler temperatures and the strong decline in summer precipitation observed in the Wonderkrater pollen record, which together likely affected the grassland summer growing season (Truc et al., 2013). Such conditions were evidently unsuitable for longer-term occupation at the site, and indeed across the Maloti-Drakensberg as a whole. But it could also be that rockshelters were simply less attractive to foragers at this time, with groups preferring open-air occupations. Such sites are extremely difficult to detect and date, with only one excavated late Pleistocene LSA example from the southern African interior identified to date (Palmison, 2014).

Conversely, while the conventional ages for level G/G2 suggest that RCC was occupied in the early LGM, our new age for this unit of >30 kcalBP calls this into question. Instead, it appears the LGM occupations were largely ephemeral and confined to the interval 20–17 kcalBP (Levels Wal and Be). The post-LGM period shows an uptick in human activity, with a peak in archaeological deposition from *c.* 11 kcalBP correlating with the radiocarbon peaks observed across the Caledon River at the two Metolong Dam sites, Ha Makotoko and Ntloana Tšoana. The available palaeoclimatic and archaeological data suggest that the shift towards a wetter but more variable climate in the summer rainfall region during the terminal Pleistocene and early Holocene greatly ameliorated conditions west of the Escarpment, attracting hunter-gatherers after a long period of relatively sparse populations.

5.2 Regional occupational trends, environmental change and hunter-gatherer mobility

The rockshelters that have been most intensively studied (and consequently dated) are amongst the largest and most prominent on the regional landscape; Sehonghong is, for example, by far the largest shelter along the upper Senqu Valley (Mitchell, pers. obs.), while RCC is similarly one of the largest and most protected sites in the eastern Free State. They would therefore presumably have been the focus of any occupation activity in a region, assuming that people chose to live in rockshelters rather than in open sites, the archaeological signals of which are generally weaker for various taphonomic reasons. It is thus plausible that the archaeological activity in the sites we have considered here is representative of human presence on the wider landscape.

Before the onset of the LGM, from *c.* 35 kcalBP, archaeological activity is documented at four of our five sites, although none of those to the west of the uKhahlamba-Drakensberg Escarpment yield chronological evidence for occupation for at least several thousand years after *c.* 29 kcalBP until *c.* 25 kcalBP when occupation resumes at both Sehonghong and RCC. Only the Strathalan sequence continues from *c.* 35 kcalBP until *c.* 25 kcalBP. Patterning in the distribution of radiocarbon dates from Sehonghong suggests that during the earliest part of the LGM, *c.* 24–23 kcalBP, the Lesotho highlands offered increased opportunities for hunter-gatherers, before conditions deteriorated sufficiently to discourage further occupation. Thereafter, the region was only ephemerally occupied until *c.* 16 kcalBP.

The timing of the LGM we use here follows a regionally appropriate definition for the summer rainfall region from Chevalier and Chase (2016) (24–17.5 ka). In the Maloti-Drakensberg Mountains, marginal glaciation is only securely, although not very tightly, dated towards the end of the LGM at *c.* 19.5–17.5 kcalBP (see review in Fitchett et al., 2016), suggesting that highland sites were abandoned prior to the development of fully stadial conditions. Stewart and colleagues (2016) have argued that highland Lesotho would have provided a refuge for groups from lower-lying areas during periods of drying or instability given their considerable attractions: greater topographic and resource diversity, an abundance of rockshelters, high quality lithic raw materials, reliable supplies of fuel, plant foods, and animals, and dependable supplies of freshwater. The Senqu Valley, in particular, may have offered one ready means of access from drier areas to the west (Stewart et al., 2016), although movement across the Front and Central Ranges of the Maloti Mountains from the Caledon Valley should also be envisaged. If coupled with extreme cold, however, such phases may have sometimes seen conditions in the highlands become unfavourable to human occupation. Indeed, to judge from the record at Sehonghong and the nearby site of Melikane (Stewart et al., 2012), it appears that during the coldest episodes (see the temperature record in Figure 5), humans in fact occupied highland rockshelters only ephemerally, if at all. The paucity of AMS dated human occupation signals at RCC (and across the Caledon River at Ha Makotoko and Ntloana Tšoana) might indicate that interior lowland environments were also unattractive to foraging groups at this time. In both cases we may be witnessing a situation in which temperature depressions and rainfall shifts had pushed resource availabilities or people's social and technological capacities beyond the thresholds needed to sustain archaeologically visible populations (Stewart and Mitchell, 2018a).

We begin to find robust evidence for human occupation covering *both* highland and lowland sites from *c.* 16 kcalBP, when local precipitation peaks after the LGM. However, the Younger Dryas stadial, which experienced markedly cooler temperatures and a sharp reduction in summer rainfall (Scott et al., 2012, Truc et al., 2013), appears to have presented a further challenge to the sustainability of the region's population since with the exception of a poorly constrained, single conventional date from the stratigraphically ephemeral layer BARF at Sehonghong (11,090 ± 230 BP, ~13.4–12.6 kcalBP, Pta-6065; Mitchell, 1995) neither highland nor lowland Lesotho nor the eastern Free State offers evidence of occupation during the bulk of the period 13–11.5 kcal BP.

Renewed occupation is, however, signalled just before the end of the stadial by the Phase 7 deposits at Ha Makotoko, which have several dates calibrating at two-sigma to ~12.0–10.3 kcalBP (Mitchell and Arthur, 2014). Thereafter, we see Rose Cottage Cave and the two Metolong sites being repeatedly used, as evidenced by the accumulation of thick deposits of early Holocene age at all three sites dated to 11.2–8.2 kcal BP. To judge from the sequence at Sehonghong, however, Lesotho's highlands were occupied on a much more punctuated basis, with multiple (but perhaps short-lived) visits marking layer SA between 11.5 and 10.5 kcal BP. Perhaps relative to MIS 2, the lower temperatures and more rugged terrain of the Senqu Valley and its adjacent mountains meant that the resource opportunities they offered were now relatively less appealing than those of lower-lying areas such as the Caledon Valley or, with increasing evidence from at least (but quite possibly before) 9.6 kcal BP, the Eastern Cape Drakensberg (Opperman, 1987; Stewart and Mitchell, 2018a).

Our lithic comparisons show three important features: 1) similarly aged lithic assemblages show considerable variability; 2) lithic variables typically used to track mobility/provisioning are reliable as a multi-proxy set, but high post-LGM variability complicates interpretations; and 3) there are complex patterns of mobility and provisioning practices through the later Pleistocene/early Holocene in and around the Maloti-Drakensberg Mountains. Overall, patterns in the lithic data match broadly with the expectations set forth in Table 1. The pre-LGM pattern shows generally lower lithic discard intensity, lower core to retouched tool ratios, and higher retouched tool frequencies. This pattern matches expectations of individual provisioning systems and greater mobility across the broader region. The significant effect of site type is manifest largely in differences between Sehonghong and RCC matching expectations of greater highland mobility during the pre-LGM period. The LGM data show higher lithic discard intensity, higher core to retouched tool ratios, and lower retouched tool frequencies for an overall pattern that matches with expectations of greater place provisioning strategies and reduced mobility. This particular set of results is strongly driven by the data from Sehonghong, for which such outcomes were predicted.

The post-LGM pattern is the most variable of all three periods with lithic discard intensities showing wide ranges across all four sites, though typical values are noticeably higher than those in pre-LGM times. Core to retouched tool ratios at Sehonghong are markedly higher than at the remaining three sites, implying some continuity in provisioning systems in the highlands. The Caledon Valley sites all show considerably lower core to flake ratios, pointing to increased emphasis on individual provisioning and increased mobility. Consistent with this, retouched tool frequencies show marked increases in the Caledon River Valley, most notably at Ha Makotoko, and low frequencies at Sehonghong. However, two factors complicate interpretations of the retouched tool patterns. First, we should take care to note that many of these post-LGM retouched tools are small scrapers, which some archaeologists argue had specific functions, such as hide scraping implements (Wadley 1996, 2000; Mitchell and Arthur 2014). Their increased frequencies could reflect concern with design performance instead of group mobility. Second, low retouched tool frequencies could result from an overall dampening of the signal in contexts with high lithic discard rates as seen in some of Sehonghong's post-LGM occupations.

Comparisons of the three lithic indices across broad elevation groupings (< and > 1700 m a.s.l.), irrespective of climate phases, demonstrate some consistency within topographic zones. The higher elevation signature at Sehonghong shows greater core to flake ratios and lower retouched frequencies, both consistent with some degree of place provisioning. The core to flake ratios at lowland sites are lower and more tightly clustered, signalling increased overall mobility, especially at Ha Makotoko. Retouched tool frequencies are considerably higher at the Caledon River sites matching expectations of the individual provisioning model. The lithic discard intensity metric, however, is widely variable, with overlapping signals between the two elevation groupings reflecting the variable use of sites and potentially fluctuating durations of occupation.

The postglacial fluctuations in lithic discard intensity, retouched frequencies, and core to flake ratios at the Caledon Valley sites between 16 and 13.5 kcalBP register in the period of declining temperatures that led up to the Younger Dryas stadial of the northern hemisphere, which suggests that we may be observing climate-induced patterning. Increases in nearly all of these indices at *c.* 11 kcalBP appear to correlate with a return to warmer conditions. Overall, we see complex non-linear trends in most of the data that cannot be explained simply by the passage of time (i.e. by one lithic technocomplex following the next). Patterning of this nature aligns more closely with reconstructions of the Maloti-Drakensberg Mountains' variable palaeoenvironments, ecology, and topography.

Conspicuously missing from our discussion so far are the eastern foothills and coastal region to the east of the uKhahlamba-Drakensberg Escarpment. Despite the high number of rockshelter sequences excavated there, particularly in the Thukela Basin of KwaZulu-Natal (Mazel, 1999, 1989), the almost complete absence of sites with dates falling before, over, or immediately after the LGM is striking. The key site of Sibudu Cave north of Durban, for example, does not appear to have been occupied after *c.* 34 kcalBP until as recently as around 1000 years ago (Wadley, 2006; Wadley and Jacobs, 2004), while Umbeli Belli on the south coast of KwaZulu-Natal lacks ages between *c.* 24.9 and *c.* 17.8 ka (Bader, 2018). Only at Umhlatuzana (Kaplan, 1990) and Shongweni (Vogel et al., 1986), both immediately inland of Durban, is occupation evident during MIS 2, yet the dating and excavation of both sites makes interpretation of these sequences difficult. At best, Umhlatuzana and Shongweni suggest that people were sporadically present some 30 km inland of the present coastline just before — and more convincingly — after the LGM.

However, the coastline of KwaZulu-Natal would have been displaced some 8–10 km eastward into what is now the Indian Ocean at times of maximum marine regression. It follows that at least a portion of the LGM archaeology for this region is probably now underwater, a possibility that would be enhanced if, as may have been the case, the region's rich shellfish and fish resources, along with the plants and animals of coastal forest habitats, allowed people to remain close to the sea all year-round (cf. Cable, 1984, who discusses this possibility for the late Holocene). One ray of light in this otherwise depressing situation is offered by a few of the finds from the late Pleistocene levels at Sehonghong. Recovery of an admittedly very small number of marine/estuarine shell ornaments from layers BAS (a *Nassarius kraussianus* bead) and RF (a *Nerita* sp. pendant and a *Trachycardium* sp. shell) points to connections to the Indian Ocean coast *c.* 24–23 and *c.* 15–14 kcal BP respectively. A vervet monkey (*Chlorocebus pygerythrus*) scapula from BAS, while not as specific, must also have been brought to the site from a significantly more wooded and thus lower-lying area as it is inconceivable that this species was present in highland Lesotho at this time (Plug and Mitchell, 2008b). Some kind of link must therefore have existed between populations in eastern Lesotho and the lowlands closer to the Indian Ocean coast using one or more passes across the escarpment, though whether this was via a process of exchange between several groups and/or involved (seasonal?) movement between the two areas, as hinted at by Carter (1978) and more fully developed by Cable (1984), we cannot yet say. Failing the relocation of the lost Alfred County Cave site (Mitchell, 1998), prospects for discovering sites of relevance able to give a coastal/lowland perspective on late Pleistocene events may, in fact, be much better in the more rural setting of Pondoland in South Africa's Eastern Cape Province (Fisher et al., 2013) than along the now heavily developed and populated south coast of KwaZulu-Natal.

5.3 Technological dynamism and behavioural variability

At the coarsest scale, the three lithic variables we have explored suggest variable and sometimes contradictory patterns of mobility and provisioning through time within the Maloti-Drakensberg region of southern Africa. Examining trends in the technological variables as indicators of mobility and provisioning strategies shows several deviations from the predicted patterns. First, some observations of low lithic discard intensity events correlate with low retouched tool frequencies, including those RCC occupations dated to between 16 and 10 kcalBP and the 16–14 kcalBP assemblages from Sehonghong. The data suggest that lithic retouch patterns may be affected by factors other than mobility constraints, such as functional specificity or task-related raw material preferences. However, these processes could themselves be impacted by group mobility and provisioning processes. Core to retouched tool ratios track retouched tool frequencies in expected ways during pre-LGM and post-LGM times, but show the inverse pattern during the LGM period. The differences between these periods could be explained in part by variability in the way toolmakers used retouched tools, i.e. use of scrapers for maintenance activities, but we need to accept that other factors such as deposition rates and variation in mobility/activity patterns are also potentially salient explanations.

These inconsistencies point to a complex relationship between technology, mobility, and provisioning practices that will require more detailed contextual information to flesh out fully. For example, the penecontemporaneous early Holocene occupations at Ha Makotoko, RCC and Sehonghong show marked variability. Ha Makotoko's Phase 6 (*c.* 10.6–10.3 kcalBP) deposits show repeated use and cleaning out of three spatially extensive and thick hearths with several interstratified secondary hearth features (Mitchell and Arthur, 2014). The same deposits also contain grass bedding, ostrich eggshell beads and fragments, and grooved sandstone artefacts for bead production. Levels DCM and LB (*c.* 10.9–10.4 kcalBP) at RCC, in contrast, show smaller assemblages and hearths with more constrained spatial patterning (Wadley, 1996). These two levels occur in the same stratigraphic horizon, leading Wadley to argue that they may even be activity variants occurring at the same time interval. Our new ages confirm this observation. Level LB contains two small hearths, a clearly identifiable primary bladelet production area, and an otherwise low density of stone and faunal material. Ground stone is more common in level LB than in any other layer at RCC. Level DCM also contains two small hearths, with a cache of unworked CCS nodules. Sehonghong's layer SA (*c.* 11.5–8.0 kcalBP) has only one hearth with very few other features and its lithic assemblage had low bladelet frequencies, very few formal tools, and a greater diversity of pigment use. Ostrich eggshell and marine shell beads are, however, far more common here than at either Ha Makotoko or RCC. Although these occupation horizons are all dated to approximately the same time, they show widely variable occupation and technological patterns, reinforcing the idea that the Pleistocene/Holocene transition witnessed considerable shifts in people's use of space within rockshelters, and challenging preconceptions about the behavioural uniformity of this 'transition'.

We must also consider the distinct possibility, as demonstrated elsewhere in southern Africa (Low et al., 2017), that rockshelters represent only one component in hunter-gatherers' mobility and technological cycles. Focused only on shelter deposits, we are witness to brief snapshots of how humans organize and provision unique places on the landscape, not the entire system. A late Holocene open-air locality dominated by fish remains alongside the Senqu River in highland Lesotho, Likoaeng, demonstrates one type of late Pleistocene site that may exist in this region (Mitchell et al., 2011), though for now the stratigraphically more ephemeral, albeit multi-component, open-air site of Erfkroon in the central Free State stands alone and, unlike Likoaeng, has virtually no associated botanical or faunal remains (Palmison, 2014).

Our new dates from RCC and other sites (e.g. Mitchell and Arthur, 2014; Pargeter et al., 2017) and review of the associated lithic information contribute to a growing set of data showing that technological changes across the late Pleistocene are more complex than previously assumed. Traditional culture-historical taxonomies focused on measuring similarities and differences among lithic industries and other archaeologically constructed entities overlook considerable variability in humans' use of space (Shea, 2014). Instead, they join analyses increasingly seeking to measure behavioural variability, such as settlement patterns, the organization of technology, and their relationships to larger evolutionary processes (Lycett and von Cramon-Taubadel, 2015; O'Brien et al., 2016; Scerri et al., 2014). Such analyses will, we hope, allow southern African hunter-gatherer archaeology to contribute ever more strongly to building a more behaviourally focused hunter-gatherer archaeology in the region in line with emerging trends (e.g. Dusseldorp, 2012; Mackay, 2016; Pargeter, 2017; Stewart and Mitchell, 2018b).

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